DEPARTMENT OF THE ARMY CORPS OF ENGINEERS

BEACH EROSION BOARD
OFFICE OF THE CHIEF OF ENGINEERS

BEHAVIOR OF BEACH FILL AND BORROW AREA AT HARRISON COUNTY, MISSISSIPPI

TECHNICAL MEMORANDUM NO.107

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CORPS OF ENGINEERS

AUGUST 1958

FOREWORD

This report presents the results of a study of movement of beach material made in connection with a beach fill operation at Harrison County, Mississippi. The beach fill was placed by the county in accordance with a plan developed by the Corps of Engineers.

In addition to its mission for studying erosion problems of specific localities, the Beach Erosion Board has the mission of making general investigations to determine suitable methods, in general, for the protection, restoration and development of beaches. The study reported herein was made under the part of the Board's general investigations program concerning the results obtained by work completed under shore protection projects and to develop criteria for the design of beach fill projects.

The most economical method of protecting long reaches of shore is frequently by artificial placement of suitable sand to provide a protective beach and maintaining the required beach dimensions by periodically replacing the material eroded from the beach zone by waves and currents. This type of protective work is being used at a number of places along the shore line of the United States. The beach fill project for Harrison County is considered of particular interest since the fill material was taken from the nearby offshore zone. At the present time there are no established criteria as to the optimum distance from the beach zone for offshore borrow areas, and only limited data are available on the behavior of this type of borrow material when placed in the beach zone. The purpose of this study was to compile all available survey data for the Harrison County project and determine the behavior of the beach fill and borrow area. Additional studies on this and similar projects will be necessary before definite relationships and limitations may be established between offshore borrow and beach zones; however, the data and observations presented herein will aid in reaching the ultimate objective.

The report was prepared by George M. Watts, Assistant Chief of the Engineering Division of the Beach Erosion Board, under the supervision of Jay V. Hall, Jr., Chief of the Division. The field data used herein were obtained by Harrison County and the U. S. Army Engineer District, Mobile. At the time this report was prepared, the technical staff of the Board was under the supervision of Major General Charles G. Holle, President of the Board. R. O. Eaton was Chief Technical Advisor. The report was edited for publication by A. C. Rayner, Chief, Project Development Division.

This report is published under authority of Public Law 166, 79th Congress, approved July 31, 1945.

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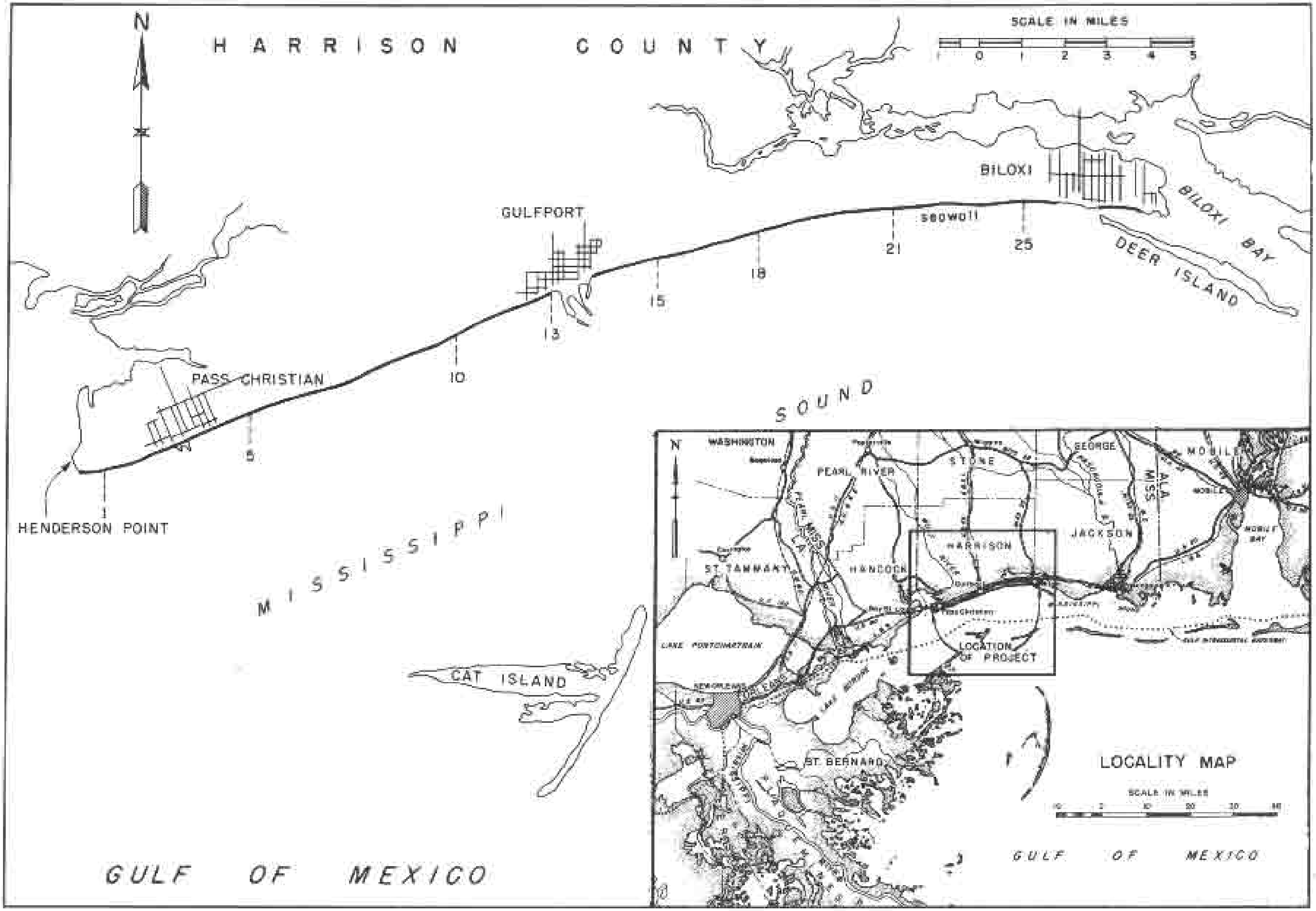

FIGURE I. PROJECT LOCATION AND SURVEY RANGES

BEHAVIOR OF BEACH FILL AND BORROW AREA AT HARRISON COUNTY, MISSISSIPPI

by
George M. Watts
Assistant Chief, Engineering Division
Beach Erosion Board

INTRODUCTION

During the period 1925 to 1928 authorities of Harrison County, Mississippi constructed a seawall to protect most of the county's 27 miles of Gulf shore and U. S. Highway No. 90 between the entrances to Biloxi and St. Louis Bays. The locality is shown on Figure 1. The wall is a reinforced concrete stepped-type structure about 24 miles in length. Its initial cost was about $3,400,000.

When the seawall was constructed a beach 80 to 100 feet wide at an elevation of about 2 feet above mean Gulf level fronted about 90 percent of the length of the wall. This protective beach in front of the seawall was gradually eroded, thus exposing the sheet-pile curtain wall at the toe of the seawall. Deterioration of the sheet-pile curtain wall allowed undermining of the seawall and loss of the sand backfill from the landward side of the seawall. Hurricane conditions accelerated losses of sand from the beach and damage to the seawall. In 1944 the Beach Erosion Board in cooperation with Harrison County completed a study of the shore protection problem. The Board recommended immediate initiation of repair to the seawall, the construction of an artificial beach, and appropriate maintenance of the seawall and beach. Another cooperative beach erosion study was completed in 1948. This study supplemented the previous one and determined the extent of Federal participation in view of the policy of Federal assistance expressed in Public Law 727, 79th Congress. In this study* the Beach Erosion Board recommended Federal participation in the costs of repair of the seawall and its protection by the construction of a beach from Biloxi Lighthouse to Henderson Point. The recommended beach was to have a berm elevation of 5 feet above mean sea level and a width of 300 feet. The estimated quantity of sand required to construct this beach was approximately 5,700,000 cubic yards.

*Report of District Engineer, Corps of Engineers, Mobile, Alabama, published in House Document No. 682, 80th Congress.

SUMMARY OF PHYSICAL DATA

Harrison County is located on Mississippi Sound approximately midway between Mobile, Alabama and New Orleans, Louisiana, as shown on Figure 1. Mississippi Sound is separated from the Gulf of Mexico by a chain of low, narrow islands located from 8 to 12 miles offshore of the area.

Easterly winds are somewhat predominant in the Gulf area off the Mississippi coast. The tides in the area are chiefly diurnal with a mean range of 1.6 feet. Higher tidal stages are caused by storms, especially those of hurricane intensity passing this portion of the Gulf coast. A hurricane in 1947 caused the water surface to rise to about 13 or 14 feet above mean Gulf level at Pass Christian.

The shore line of Harrison County is exposed chiefly to waves generated in Mississippi Sound and, due to the limited fetch and relatively shallow water in the sound, the waves are usually small. Waves generated during hurricane conditions are much larger and generally cause considerable damage to structures located near the shore. Wave data* and hurricane wave statistics**, based on hindcasts from weather data, have been compiled for a point offshore from Burwood, Louisiana. Certain of these data are applicable to the Gulf side of the islands separating Mississippi Sound.

PROJECT CONSTRUCTION

Under the project recommended by the Corps of Engineers for Harrison County, repair of the seawall was initiated by the county in 1950. The sidewalk which was a part of the seawall was removed and the broken concrete used to construct a barrier type groin at Henderson Point. The beach fill was placed from Biloxi Lighthouse to Henderson Point between January and November 1951. Fill material for the beach was dredged from the offshore zone in Mississippi Sound and deposited in front of the wall by pipeline. The borrow channel was located about 1500 feet offshore, essentially parallel to the shore, and was dredged to a depth of about 14 feet. The total quantity of fill was slightly less than 6,000,000 cubic yards including 169,000 cubic yards of backfill behind the seawall. The

*"Wave Statistics for theGulf of Mexico Off Burwood, Louisiana", Beach Erosion Board Technical Memorandum No. 87, Oct. 1956.

**"Hurricane Wave Statistics for the Gulf of Mexico", Beach Erosion Board Technical Memorandum No. 98, June 1957.

drainage system from the landward side of the seawall to the Gulf was also reconstructed. The cost of the project totalled $3,001,780.*

No sand has been added to replace losses since completion of the initial fill. The county carries out an extensive maintenance program, including such items as removal of debris from the beach, cleaning drainage lines, and removing wind-blown sand from the adjacent highway and placing this sand back on the beach.*

SURVEY DATA

In connection with the initial study of the erosion problem, profiles of the shore and offshore bottom were obtained at intervals of approximately 5,000 feet (26 profiles) along the 25-mile study area in November 1942. Sixteen of the ranges were resurveyed in February 1948 and eight again in May 1958. Range locations are shown on Figure 1, and a comparative plot of the profile data is shown on Figure 2. Beach sections, with soundings out to water depths of between 1 and 2 feet below mean low water, were made at intervals of about 5,000 feet along the shore in May 1951, May 1953, July 1954, May 1958, and at intervals of about 1,000 feet along the shore in March 1957. The beach section data were utilized to compute the volume of material moved in the beach zone. An example of the comparative beach section plots is included as Figure 3.

Sand samples were taken at two locations along all twenty-six ranges in November 1942 and at four locations along four ranges in May 1958. Table 1 presents the size analysis for samples obtained along the four ranges in 1958 and for samples obtained in 1942 along the same or adjacent ranges. Size analyses for two beach samples taken immediately and two months after the fill was placed are also included in this tabulation.

ANALYSIS OF DATA

The spacing of the ranges along the Harrison County shore in the 1942 survey, and the fact that only a limited number of these ranges were resurveyed in 1948 and 1958, limit the accuracy of determining the net material movement over the period of record. The beach sections, taken from the seawall Gulfward to a depth of about 2 feet below mean low water in 1951-53-54-57 and 58, give a

*For details see "Shore Protection in Harrison County, Mississippi", F. F. Escoffier and W. L. Dolive, Bulletin of Beach Erosion Board, Vol. 8, No. 3, July 1954, and "Maintenance of Harrison County, Mississippi Sloping Beach", A. MacArthur, Shore and Beach, Vol. 24, No. 1, April 1956.

TABLE 1

SAND SAMPLE ANALYSIS DATA

Range No.	Date	Sample Location Data: Depth From MLW (feet)	Sample Location Data: Approximate Location	Cumulative Percent Coarser, Size in MM.: 1.190	0.840	0.590	0.420	0.297	0.250	0.210	0.149	0.105	0.074	Median Diameter in MM.	Remarks
1	Apr. 1958	+0.8	Mid-tide on beach				2.9	37.6		82.6	99.8	99.9		0.271	7 yrs. after fill
1	Nov. 1942	-0.3	In front of seawall				1.0		3.0				62.0	0.088	10 yrs. before fill
1	Apr. 1958	-2.5	900' from seawall			0.9	6.4	27.7		63.6	97.5	99.5	99.8	0.240	7 yrs. after fill
1	Nov. 1942	-2.0	1600' from seawall				3.0		26.0				97.0	0.182	10 yrs. before fill
1	Apr. 1958	-7.0	1800' from seawall		0.3	0.6	5.7	14.3		25.6	41.0	45.9	49.6	0.074	℄ borrow area
1	Apr. 1958	-4.0	2200' from seawall			0.8	6.3	26.0		61.3	96.5	99.4	99.9	0.233	7 yrs after fill
9	Nov. 1942	+0.5	In front of seawall				18.0		83.0				99.0	0.325	10 yrs. before fill
9	Nov. 1942	-1.0	1200' from seawall				3.0		30.0				92.0	0.178	10 yrs. before fill
10	Apr. 1958	+0.8	Mid-tide on beach	0.5	3.4	17.2	49.4	86.5		96.6	99.8	100.0		0.420	7 yrs. after fill
10	Apr. 1958	-4.0	100' from seawall		0.6	5.6	26.5	61.6		82.7	98.0	99.6	99.8	0.330	7 yrs. after fill
10	Apr. 1958	-11.0	1700' from seawall		0.7	1.5	12.2	43.2		72.4	96.5	99.6	99.9	0.270	℄ borrow area
10	Apr. 1958	-4.0	2300' from seawall			0.2	3.8	20.8		48.8	93.0	99.2	99.8	0.210	7 yrs. after fill
11	Nov. 1942	0.0	In front of seawall				25.0		68.0				99.0	0.310	10 yrs. before fill
11	Nov. 1942	-2.0	1000' from seawall				8.0		40.0				97.0	0.215	10 yrs. before fill
17	Nov. 1942	0.0	In front of seawall				13.0		44.0				95.0	0.245	10 yrs. before fill
17	Nov. 1942	-3.0	1400' from seawall				2.0		12.0				84.0	0.128	10 yrs. before fill
18	Apr. 1958	+0.8	Mid-tide on beach	0.5	2.5	10.0	29.6	65.6		86.5	99.1	99.9	100.0	0.340	7 yrs. after fill
18	Apr. 1958	-3.0	1000' from seawall			0.6	3.8	19.7		50.6	85.2	97.3	99.7	0.212	7 yrs. after fill
18	Apr. 1958	-12.0	1700' from seawall		(Pipette Analysis; 1.1% very fine sand; 88.3% silt; 11.6% clay)									0.016	℄ borrow area
18	Apr. 1958	-3.0	2200' from seawall				1.8	18.0		49.3	95.8	98.9	99.5	0.206	7 yrs. after fill
19	Nov. 1942	+1.0	In front of seawall				17.0		55.0				84.0	0.267	10 yrs. before fill
19	Nov. 1942	-1.0	1000' from seawall				25.0		75.0				97.0	0.321	10 yrs. before fill
25	Nov. 1942	+1.0	In front of seawall				66.0		98.0				99.0	-	10 yrs. before fill
25	Nov. 1942	-1.0	500' from seawall				6.0		46.0				98.0	0.238	10 yrs. before fill
25	Apr. 1958	+0.8	Mid-tide on beach			1.3	13.7	43.0		68.0	93.8	98.9	99.6	0.272	7 yrs. after fill
25	Apr. 1958	-2.0	600' from seawall			0.7	4.6	28.3		69.6	97.4	99.4	99.9	0.253	7 yrs. after fill
25	Apr. 1958	-8.0	900' from seawall		(Pipette Analysis; 7.8% very fine sand; 56.6% silt; 35.6% clay)									0.007	℄ borrow area
25	Apr. 1958	-9.0	1400' from seawall			1.6	10.6	34.2		60.9	87.4	98.5	99.5	0.248	7 yrs. after fill
	1951		From beach foreshore after fill was placed		0.6		9.9		51.0		89.5		98.0	0.260	
	1951		From beach foreshore 2 months after fill was placed		0.4		6.3		56.4		95.4		100.0	0.270	

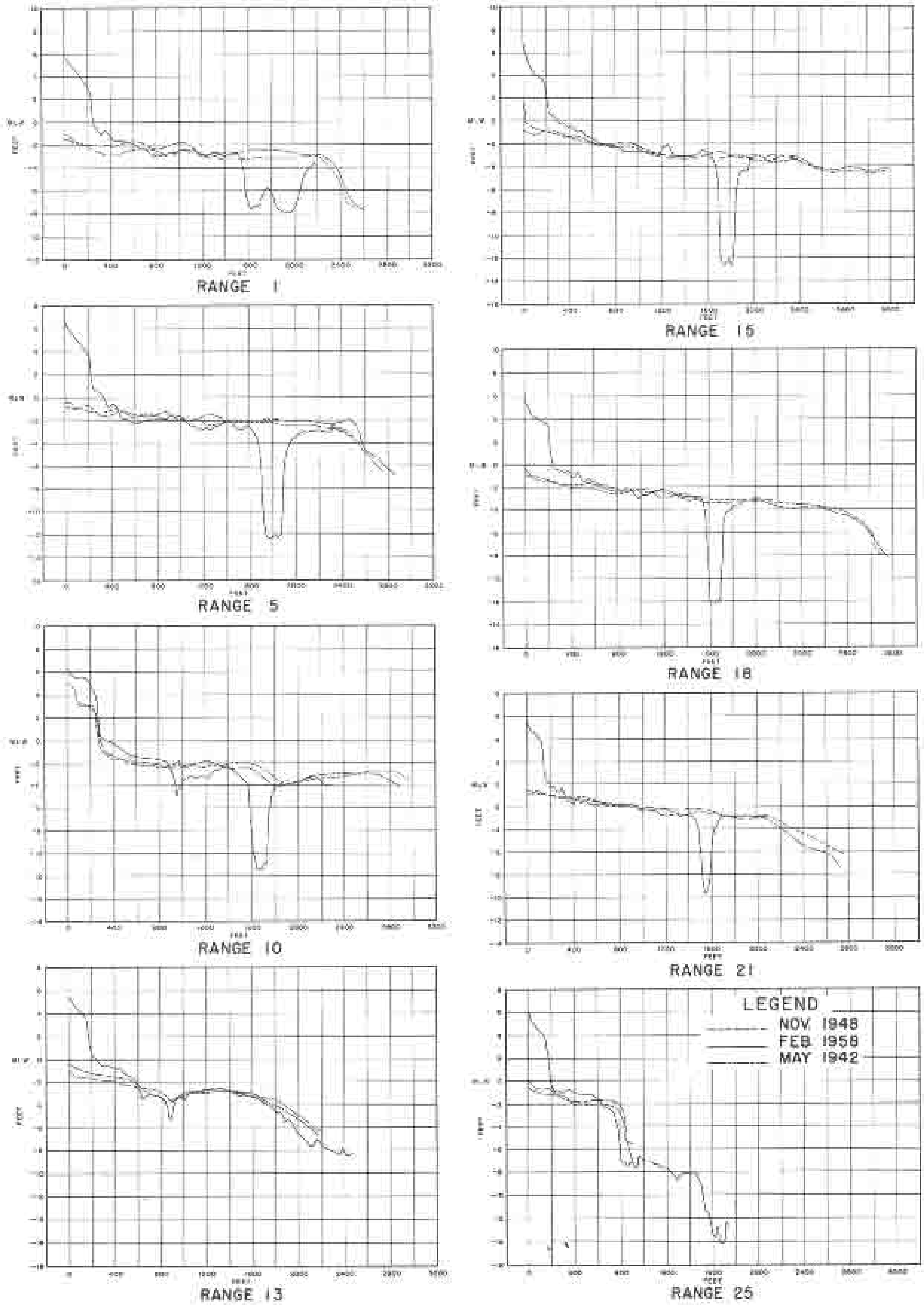

FIGURE 2. COMPARATIVE PROFILES

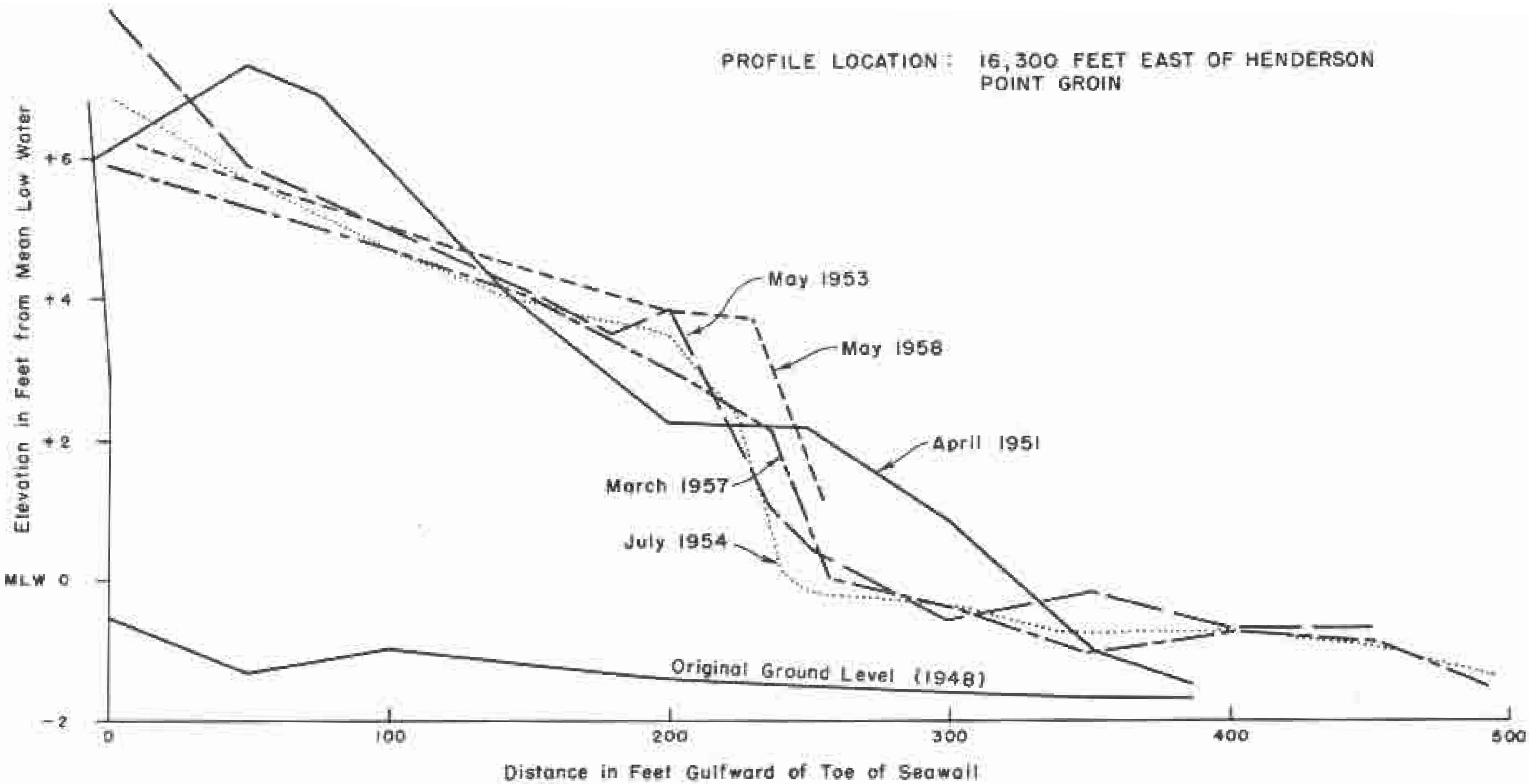

FIGURE 3. TYPICAL BEACH SECTION DATA

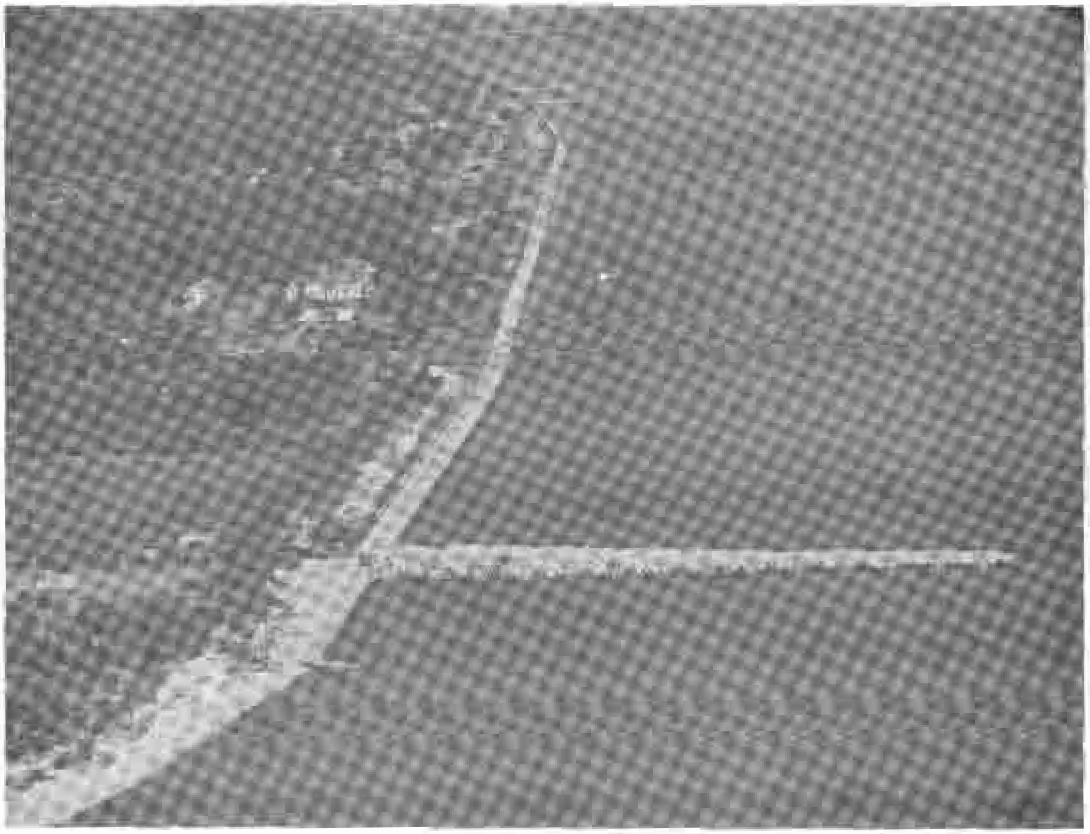

FIGURE 4. CONDITION OF BEACH EAST OF HENDERSON POINT - OCT. 1950

FIGURE 5. FINISHED BEACH EAST OF HENDERSON POINT - FEB. 1952.

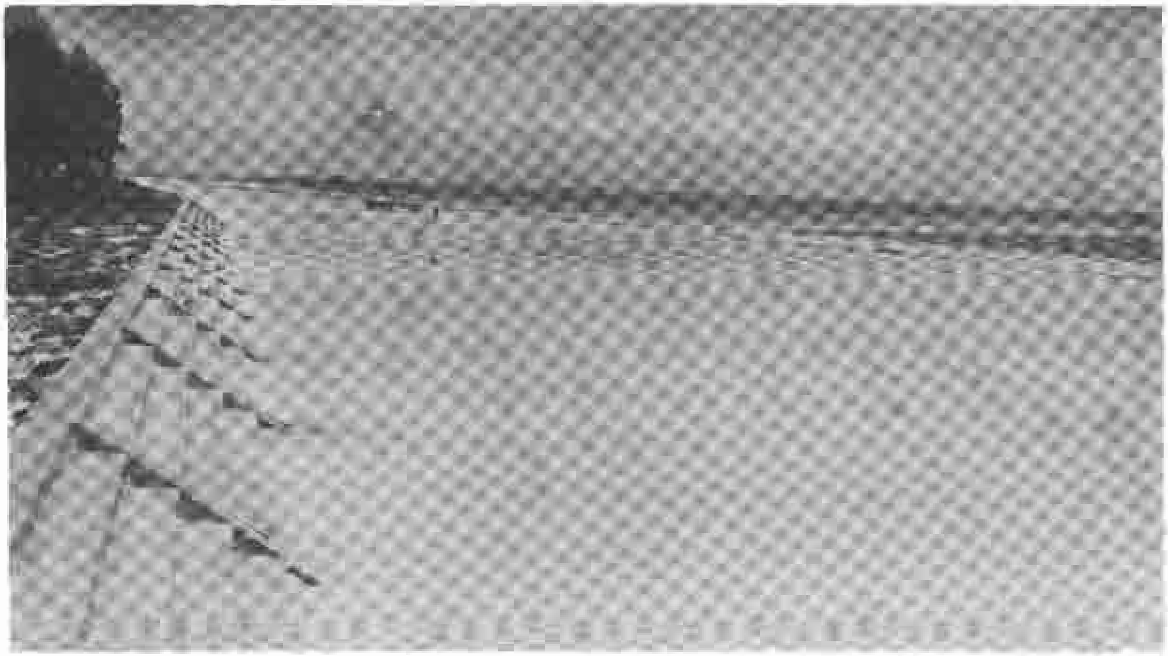

FIGURE 6. LOOKING EAST FROM HENDERSON POINT GROIN, MAY 1958

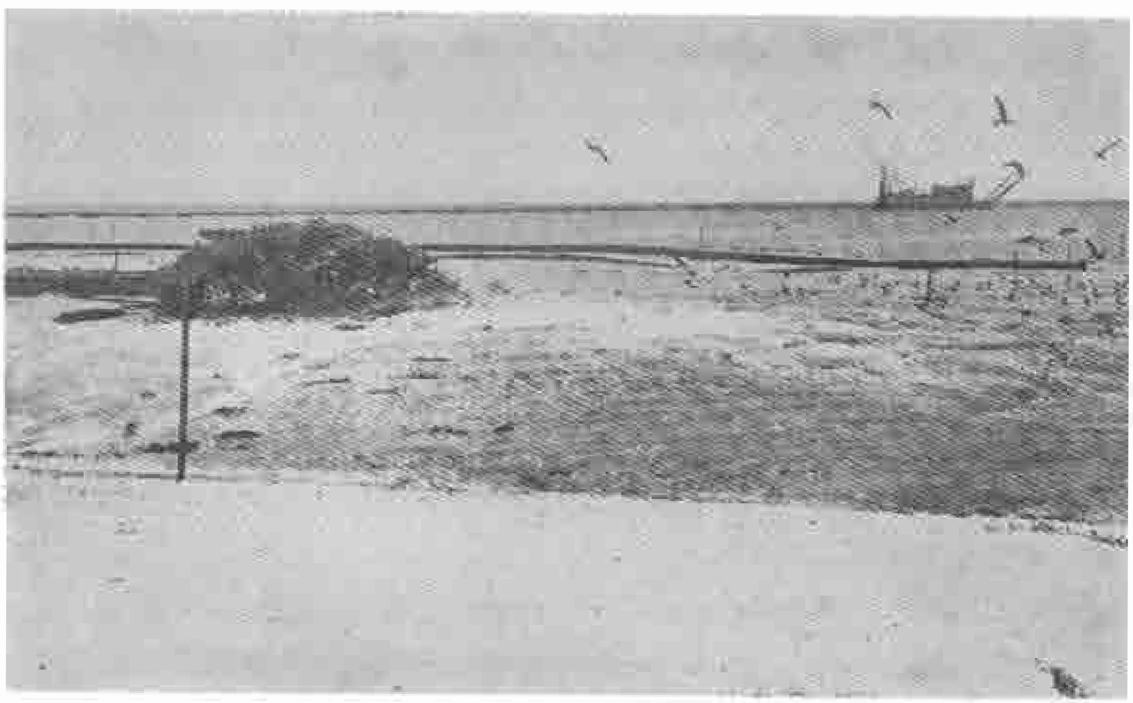

FIGURE 7. TYPICAL FILLING OPERATION

more accurate estimate of volumetric changes to that depth. However, such computed material movement only applies to the beach zone and does not reflect the material movement in the offshore zone which must be considered in the evaluation of net changes that take place on the beach over a particular period of time.

In general, the ground elevation in front of the seawall in 1942 and 1948 was about 1 foot below mean low water and the bottom slope Gulfward was about 1 on 900. The data taken in 1958 show the average beach slope from the seawall to +3 feet mean low water to be about 1 on 80, from +3 to mean low water about 1 on 16, from mean low water to -2 about 1 on 200, and from -2 to -6 from 1 on 500 to 1 on 1500.

The comparative profile plot for the eight ranges, shown on Figure 2, indicates that the 1948 and 1958 profiles generally meet at a depth of between 3 and 4 feet below mean low water, which is generally 300 to 400 feet landward of the borrow zone for the beach fill. End area computations for the 1948 and 1958 profiles, out to the point where the profiles intersect, indicate an increase of approximately 5,930,000 cubic yards between the limiting profiles. Since 5,985,000 cubic yards of sand were placed on the beach in 1951, these data would indicate that only about 55,000 cubic yards of material had been moved out of the fill area between 1951 and 1958, amounting to a net loss of less than 0.1 cubic yard per year per linear foot of shore. The wide spacing of the profiles limits the accuracy of this annual loss figure, however, the figure is undoubtedly in the right order of magnitude.

Net material movement within the beach zone was computed from the beach cross sections covering the period May 1951 to May 1958. The net change for this period between the seawall and the 2-foot depth contour (MLW) throughout the alongshore study limits was depletion in the amount of approximately 700,000 cubic yards, or an average material movement of about 100,000 cubic yards per year. This is an average material movement of about 0.8 cubic yard per linear foot of shore within the study limits. The survey data do not indicate definite net alongshore material movement. Comparative aerial photographs and visual inspection of the study area suggest a slightly net westerly movement, however, in view of the smaller loss of material out to the intersection of the 1948 and 1958 profiles, the data tend to indicate the material removed from the beach zone by wave action is transported to the offshore zone and very little is transported alongshore and beyond the study limits.

The offshore borrow channel for the 1951 beach fill is shown on the comparative profile plot in Figure 2. In the field survey of April 1958, the axis of the channel was located by systematically (zigzag course) sounding between the established range lines (basic data of this alongshore sounding between ranges are not included in this report). These soundings along the channel axis were used to obtain an approximation of the present capacity of the borrow channel (4,000,000 cubic yards). The original capacity of the channel is assumed to be about 6,000,000 cubic yards since approximately that volume of sand was placed on the beach. Therefore shoaling has reduced the capacity of the channel by about one-third, or at a rate of about 5 percent per year. Since the 1948 and 1958 profiles intersect some 300 to 400 feet landward of the borrow channel, it appears that virtually none of the sand fraction of the original borrow material has been transported from the beach zone back into the borrow channel nor that the offshore slope adjustment of the original fill has reached the borrow channel.

The bottom sand sample data for April 1958 indicate there is a gradual reduction in size gradation with increase of water depth along the profile. Only two samples were taken along each profile in November 1942 but, in general, these data also show a reduction in material size with increasing depth. The sand analysis data also indicate there is no apparent trend or systematic variation of the bottom material alongshore within the limits of the study area. Samples taken in front of the seawall in 1942 had median sizes from 0.088 to greater than 0.500 millimeter, which could be expected since a very limited beach zone existed in front of the seawall in 1942. Some variation in the median size was indicated by samples taken in 1958 along the mean tide line on the beach, however as an average, the median size is about 0.32 millimeter. Only limited cases exist where samples were taken in 1942 and 1958 on the same ranges at comparable water depths. For these cases the data indicate the material to be of a coarser gradation (for comparable water depths) in 1958. The median diameter of the fill material placed in front of the seawall in 1951 was indicated to be 0.27 millimeter and, as of April 1958, material of this median diameter is found in about 4 feet of water (mean low water datum). About 65 percent of the fill material was finer than 0.3 millimeter in diameter, about 10 percent was finer than 0.15 millimeter in diameter, and only about 2 percent was finer than the lower limit of sand sizes (0.074 millimeter).

With one exception (Range 10) the material on the present bottom of the offshore borrow channel is composed chiefly of material in the silt range with a relatively small percentage of sand.

DISCUSSION

The survey data obtained in 1958 allow an estimate to be made of the net movement of the fill material placed in 1951. The wide spacing of ranges introduces some error in such volumetric computations, however, the results are undoubtedly representative of the magnitude and direction of material movement. The material movement from the beach zone amounted to about 0.8 cubic yard per year per linear foot of shore, however, computations which include the offshore zone to a point of intersection of the profiles indicate the overall material movement out of the study area to be less than 0.1 cubic yard per year per linear foot of shore. Thus virtually 90 percent of the material eroded from the beach zone has apparently been transported directly to the offshore zone, as a slope adjustment, and therefore cannot be considered as lost from the beach zone. The material transported from the beach to the offshore zone serves to stabilize the nearshore bottom slopes, hence much wave energy is dissipated at a more seaward position, which means the beach is still providing a definite degree of protection to the backshore. The progressive offshore bottom slope adjustment may eventually reach the landward edge of the borrow channel. Until this channel is filled it appears unlikely that any beach material could pass from the landward to the Gulfward side thereof. A gradual reduction in rate of material movement from the beach zone may be expected as the profile adjusts to a flatter slope, therefore, the required rate of artificial nourishment, in order to maintain a width of 300 feet or more, would be between 0.1 and 0.8 cubic yard per year per linear foot of shore. It would be reasonable to assume that the average annual requirement over the estimated life of the project would not exceed 0.5 cubic yard per year per linear foot of shore, or a total annual replenishment of approximately 60,000 cubic yards. Although there may be localized points between the study limits where beach replenishment would be required after severe storm conditions had prevailed, the present data would indicate that major beach replenishment will not be required for at least the next 20 years. Since no net alongshore movement of material is evident, artificial beach replenishment should be in the form of direct placement along the beach rather than stockpiling the material at points along the shore and allowing these stockpiles to act as feeder beaches.

Assuming a project life of 50 years, the annual charges for the project may be estimated as follows:

Interest on initial investment in beach fill, excluding seawall repair but including appurtenant drainage system $2,650,000 @ 3%	$80,000
Amortization	24,000
Nourishment 60,000 cu. yds. @ 50¢	30,000
Total	$134,000

Considering the 120,000 feet of Gulf shore line, shore stability is obtained at approximately \$1.10 per linear foot per year. In comparison the annual charges of the existing seawall may be estimated as follows:

Interest on initial investment \$3,400,000 @ 3%	\$102,000
Amortization	30,000
Maintenance (assume average based on 1950 repairs at end of 22 years \$350,000/22)	16,000
Total	\$148,000

Approximate cost of the seawall per year per linear foot of shore would be \$1.20. If the initial investment for the beach fill and seawall project is adjusted to 1958 construction costs, the respective annual charges would be about \$1.40 and \$4.10. It must be recognized however that the beach fill would not provide complete protection to the highway from a severe storm or hurricane such as that of 1947 when the water level in Mississippi Sound was as much as 8 or 9 feet above the present beach elevation; also that the wall alone did not provide complete protection during that hurricane. A modification of either or both structures would be required for complete protection to the backshore during such conditions. It seems apparent that both features must be maintained in their present condition for a high degree of protection to the backshore, the wall for protection of the backshore and the beach for protection of the wall during extreme storm conditions. The beach has, in addition, important benefits resulting from its use for recreational purposes.

The 1958 data show the slopes of the beach and bottom to be about 1 on 200 for the offshore zone seaward of mean low water, about 1 on 16 within the tidal zone, and about 1 on 80 between mean high water line and the seawall; however, this latter section of the beach was mechanically graded to fill depressions left after the initial profile adjustment by waves, therefore, the present slope in this zone is not the direct result of wave action. The present width of the beach in front of the seawall at mean Gulf level ranges from 325 to 375 feet, which compares favorably with the 300-foot width of the original design. Slope adjustment of fill material appears to have been effected out to about the 3-foot depth below mean low water over the past 7 years. The offshore slope adjustment has been a rather slow process, due to the excellent quality of the fill material and the mild wave climate in this area. Whether the adjustment to normal wave conditions has been completed cannot be determined at this time.

The present condition of the offshore borrow channel indicates that it is filling at a rather slow rate. Gulfward progression of the toe of the beach fill, if it has not yet been completed, may eventually cause the channel to fill at a more rapid rate. Therefore, the rate of filling over the past 7 years is not necessarily indicative of the future filling rate. It appears that the offshore distance of the borrow channel was a nearly optimum selection. Had the channel been selected at a position 300 or 400 feet closer to shore, the finer sand fraction of the beach fill would be depositing in the channel at the present time, with the resultant need of earlier artificial nourishment. Had the channel been selected at a more Gulfward position, greater distance between the beach fill and borrow channel would exist for progressive bottom slope adjustment, which might lengthen the effective life of the beach fill without nourishment; however, it cannot be determined at this time whether that advantage would offset the additional pumping costs.

The sampling data indicate that the borrow channel is presently filling with sediment in the silt range, even though the bottom material on the landward and Gulfward sides of the channel cut is chiefly sand. This type of material shoaling is reported to be common for artificially cut channels in the Gulf coastal areas. The field data in this study do not provide a definite clarification of the mechanics of this type of channel shoaling, but do suggest that the shoaling is a result of sorting action by waves and other currents. The wave climate in the study area is usually mild, however, the local wind-generated waves are, on frequent occasions, of sufficient size to have maximum orbital velocities slightly greater than that required to transport the silt and finer fraction into suspension. The suspended material transported into the borrow channel area by either wave-induced or other currents eventually settles out of suspension when these currents reduce in strength; hence the shoal material in the cut contains a preponderance of silt and smaller sizes.

CONCLUSIONS

The study has resulted in the following conclusions:

a. The beach fill has provided the required protection to the seawall and highway at low cost over the first 7 years of the project life.

b. The stability of the beach fill and relatively slow offshore slope adjustment have demonstrated the suitability of the fill material.

c. The location of the borrow channel was suitable for the wave conditions which have occurred in Mississippi Sound since placement of the fill; however, the data do not materially aid in advancing criteria for general design of offshore borrow zones.

d. Shoaling of the borrow channel has as yet been limited to silty material presumably sorted from the fill and adjacent bottom by waves and currents.

BEACH EROSION BOARD, C. E., U. S. ARMY,
WASHINGTON, D. C.

BEHAVIOR OF BEACH FILL AND BORROW AREA AT HARRISON COUNTY, MISSISSIPPI, By G. M. Watts, Sept. 1958, 14 pp., 7 illus., 1 table. Tech. Memo. No. 107

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2. Beach Fill
3. Mississippi - Artificial Nourishment - Harrison Co.
4. Harrison Co., Miss.

I. Watts, G. M.
II. Title

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BEHAVIOR OF BEACH FILL AND BORROW AREA AT HARRISON COUNTY, MISSISSIPPI, By G. M. Watts, Sept. 1958, 14 pp., 7 illus., 1 table. Tech. Memo. No. 107

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Survey and sand sample data were analyzed to determine the behavior of beach fill placed along 25 miles of shore in 1951 from an offshore borrow source. Material losses since placement have been slight, amounting to less than 0.1 cubic yard per year per linear foot of shore. The stability of the beach fill and relatively slow offshore slope adjustment demonstrates the suitability of original fill material. Shoaling of the borrow area has been slow and limited to material of silt size.

1. Artificial Nourishment
2. Beach Fill
3. Mississippi - Artificial Nourishment - Harrison Co.
4. Harrison Co., Miss.

I. Watts, G. M.
II. Title